# LM4927 Boomer™ Audio Power Amplifier Series 2.5 Watt Fully Differential Audio Power Amplifier With Shutdown

**Check for Samples: LM4927**

## FEATURES

- **Fully Differential Amplification**
- **Available in Space-Saving Micro-Array WSON Package**
- **Ultra Low Current Shutdown Mode**
- **Can Drive Capacitive Loads up to 100pF**
- **Improved Pop & Click Circuitry Eliminates Noises During Turn-On and Turn-Off Transitions**
- **2.4 - 5.5V Operation**
- **No Output Coupling Capacitors, Snubber Networks or Bootstrap Capacitors Required**

## APPLICATIONS

- **Mobile Phones**
- **PDAs**
- **Portable Electronic Devices**

## KEY SPECIFICATIONS

- **Improved PSRR at 217Hz, 85dB (Typ)**
- **Power Output at 5.0V @ 10% THD (4Ω), 2.5W (Typ)**
- **Power Output at 3.3V @ 1% THD, 550mW (Typ)**
- **Shutdown Current, 0.1µA (Typ)**

## DESCRIPTION

The LM4927 is a fully differential audio power amplifier primarily designed for demanding applications in mobile phones and other portable communication device applications. It is capable of delivering 2.5 watts of continuous average power to a 4Ω load with less than 10% distortion (THD+N) from a $5V_{DC}$ power supply.

Boomer audio power amplifiers were designed specifically to provide high quality output power with a minimal amount of external components. The LM4927 does not require output coupling capacitors or bootstrap capacitors, and therefore is ideally suited for mobile phone and other low voltage applications where minimal power consumption is a primary requirement.

The LM4927 features a low-power consumption shutdown mode. To facilitate this, Shutdown may be enabled by logic low. Additionally, the LM4927 features an internal thermal shutdown protection mechanism.

The LM4927 contains advanced pop & click circuitry which eliminates noises which would otherwise occur during turn-on and turn-off transitions.

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## Typical Application

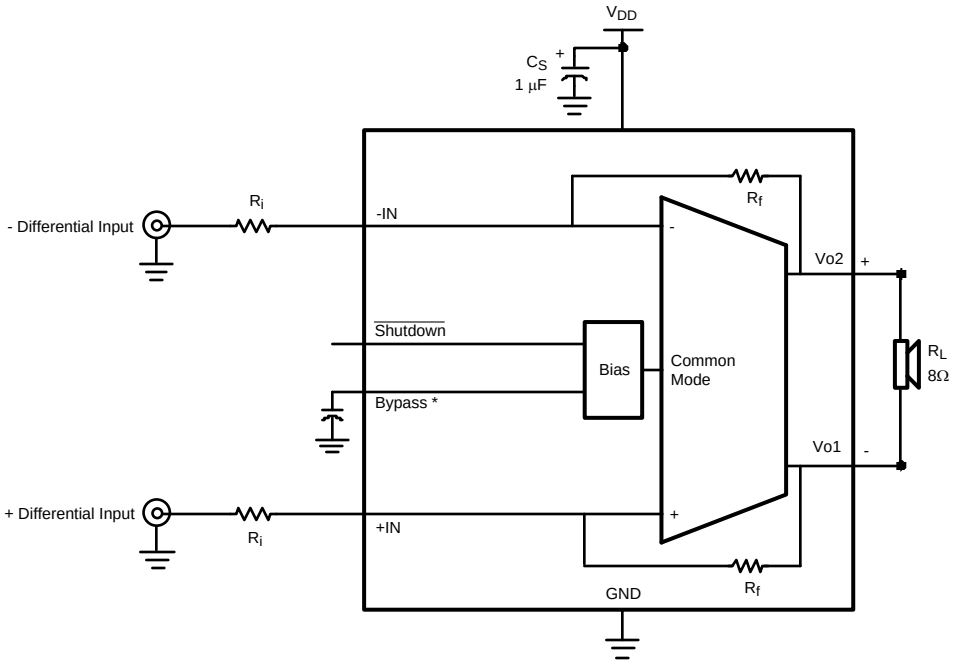



**Figure 1. Typical Audio Amplifier Application Circuit**

## Connection Diagram

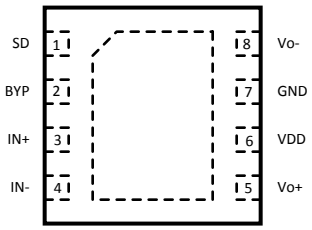



**Figure 2. 8 Pin WSON Package**
**Top View**
**See Package Number NGQ0008A**

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.


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## Absolute Maximum Ratings(1)(2)

| | | |
|---|---|---|
| Supply Voltage | | 6.0V |
| Storage Temperature | | −65°C to +150°C |
| Input Voltage | | −0.3V to $V_{DD}$ +0.3V |
| Power Dissipation(3) | | Internally Limited |
| ESD Susceptibility(4) | | 2000V |
| ESD Susceptibility(5) | | 200V |
| Junction Temperature | | 150°C |
| Thermal Resistance | $\theta_{JA}$ (SD) | 63°C/W |
| Soldering Information(6) | See AN-1187 (SNOA401) | |

(1) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Operating Ratings* indicate conditions for which the device is functional, but do not ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(3) The maximum power dissipation must be derated at elevated temperatures and is dictated by $T_{JMAX}$, $\theta_{JA}$, and the ambient temperature $T_A$. The maximum allowable power dissipation is $P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA}$ or the number given in Absolute Maximum Ratings, whichever is lower. For the LM4927, see power derating curve for additional information.
(4) Human body model, 100pF discharged through a 1.5kΩ resistor.
(5) Machine Model, 220pF – 240pF discharged through all pins.
(6) When driving 4Ω loads from a 5V power supply, the LM4927LD must be mounted to a circuit board with the exposed-DAP area soldered down to a $1in^2$ plane of 1oz, copper.

## Operating Ratings

| | | |
|---|---|---|
| Temperature Range | $T_{MIN} \le T_A \le T_{MAX}$ | $-40°C \le T_A \le 85°C$ |
| Supply Voltage | | $2.4V \le V_{DD} \le 5.5V$ |

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## Electrical Characteristics $V_{DD}$ = 5V(1)(2)

The following specifications apply for $V_{DD}$ = 5V, $A_V$ = 1, and 8Ω load unless otherwise specified. Limits apply for $T_A$ = 25°C.

| Symbol | Parameter | Conditions | LM4927 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typical(3) | Limit(4) | |
| $I_{DD}$ | Quiescent Power Supply Current | $V_{IN}$ = 0V, no load<br>$V_{IN}$ = 0V, $R_L$ = 8Ω | 2.2<br>2.2 | 4.5<br>4.5 | mA (max) |
| $I_{SD}$ | Shutdown Current | $V_{SHUTDOWN}$ = GND | 0.1 | 1 | µA (max) |
| $P_o$ | Output Power | THD = 1% (max); f = 1 kHz<br>$R_L$ = 4Ω<br>$R_L$ = 8Ω | <br>2.1<br>1.30 | <br><br>1.20 | <br><br>W (min) |
| | | THD = 10% (max); f = 1 kHz<br>$R_L$ = 4Ω<br>$R_L$ = 8Ω | <br>2.5<br>1.6 | <br><br> | <br><br>W |
| THD+N | Total Harmonic Distortion+Noise | $P_o$ = 1 Wrms; f = 1kHz | 0.03 | | % |
| PSRR | Power Supply Rejection Ratio | $V_{ripple}$ = 200mV sine p-p | | | |
| | | f = 217Hz(5) | 90 | | dB (min) |
| | | f = 1kHz(5) | 85 | 71 | |
| CMRR | Common-Mode Rejection Ratio | f = 217Hz, $V_{CM}$ = 200m$V_{pp}$ | 60 | | dB |
| $V_{OS}$ | Output Offset | $V_{IN}$ = 0V | 4 | | mV |
| $V_{SDIH}$ | Shutdown Voltage Input High | | | 1.4 | V (min) |
| $V_{SDIL}$ | Shutdown Voltage Input Low | | | 0.4 | V (max) |
| SNR | Signal-to-noise ratio | $P_O$ = 1W, f = 1kHz | 110 | | dB |
| $R_F$ | Internal Feedback Resistance | $R_i$ = 40kΩ | 40 | 37 | kΩ (min) |
| | | | | 47 | kΩ (max) |
| $A_V$ | Gain | $R_i$ = 40kΩ | 0 | –0.68<br>1.4 | dB (min)<br>dB (max) |
| $T_{WU}$ | Wake-up time from Shutdown | Cbypass = 1µF | 14 | | ms |

(1) All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Operating Ratings* indicate conditions for which the device is functional, but do not ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
(3) Typicals are measured at 25°C and represent the parametric norm.
(4) Limits are specified to Texas Instruments' AOQL (Average Outgoing Quality Level).
(5) 10Ω terminated input.


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## Electrical Characteristics $V_{DD}$ = 3V(1)(2)

The following specifications apply for $V_{DD}$ = 3V, $A_V$ = 1, and 8Ω load unless otherwise specified. Limits apply for $T_A$ = 25°C.

| Symbol | Parameter | Conditions | LM4927 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typical(3) | Limit(4) | |
| $I_{DD}$ | Quiescent Power Supply Current | $V_{IN}$ = 0V, no load<br>$V_{IN}$ = 0V, $R_L$ = 8Ω | 2<br>2 | 4.3<br>4.3 | mA (max) |
| $I_{SD}$ | Shutdown Current | $V_{SHUTDOWN}$ = GND | 0.1 | 1 | µA (max) |
| $P_o$ | Output Power | THD = 1% (max); f = 1 kHz<br>$R_L$ = 4Ω<br>$R_L$ = 8Ω | <br>0.650<br>0.450 | | <br>W |
| | | THD = 10% (max); f = 1 kHz<br>$R_L$ = 4Ω<br>$R_L$ = 8Ω | <br>0.800<br>0.550 | | <br>W |
| THD+N | Total Harmonic Distortion+Noise | $P_o$ = 0.25Wrms; f = 1kHz | 0.04 | | % |
| PSRR | Power Supply Rejection Ratio | $V_{ripple}$ = 200mV sine p-p | | | |
| | | f = 217Hz(5) | 85 | | dB |
| | | f = 1kHz(5) | 80 | | |
| CMRR | Common-Mode Rejection Ratio | f = 217Hz, $V_{CM}$ = 200m$V_{pp}$ | 60 | | dB |
| $V_{OS}$ | Output Offset | $V_{IN}$ = 0V | 4 | | mV (max) |
| $V_{SDIH}$ | Shutdown Voltage Input High | | | 1.4 | V (min) |
| $V_{SDIL}$ | Shutdown Voltage Input Low | | | 0.4 | V (max) |
| $T_{WU}$ | Wake-up time from Shutdown | Cbypass | 8 | | ms |

(1) All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Operating Ratings* indicate conditions for which the device is functional, but do not ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
(3) Typicals are measured at 25°C and represent the parametric norm.
(4) Limits are specified to Texas Instruments' AOQL (Average Outgoing Quality Level).
(5) 10Ω terminated input.

## External Components Description

(See Figure 1)

| Components | | Functional Description |
|---|---|---|
| 1. | $C_S$ | Supply bypass capacitor which provides power supply filtering. Refer to the POWER SUPPLY BYPASSING section for information concerning proper placement and selection of the supply bypass capacitor. |
| 2. | $C_B$ | Bypass pin capacitor which provides half-supply filtering. Refer to the section, PROPER SELECTION OF EXTERNAL COMPONENTS, for information concerning proper placement and selection of $C_B$. |
| 3. | $R_i$ | Inverting input resistance which sets the closed-loop gain in conjunction with $R_f$. |
| 4. | $R_f$ | Internal feedback resistance which sets the closed-loop gain in conjunction with $R_i$. |

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## Typical Performance Characteristics(1)

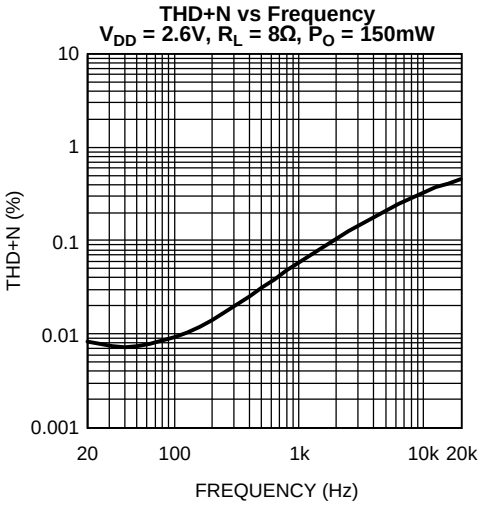



**Figure 3.**

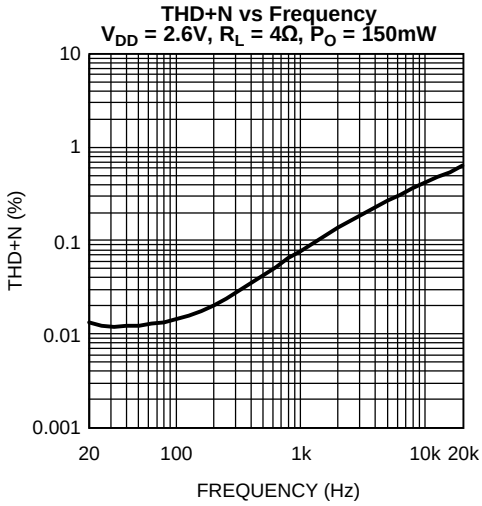



**Figure 4.**

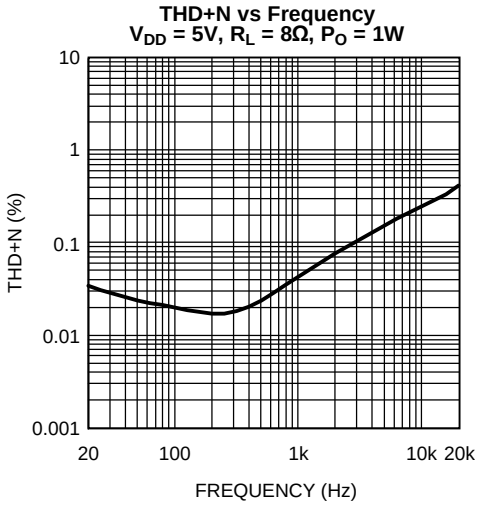



**Figure 5.**

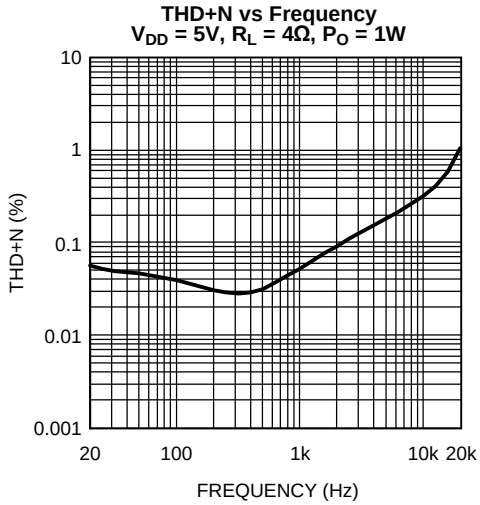



**Figure 6.**

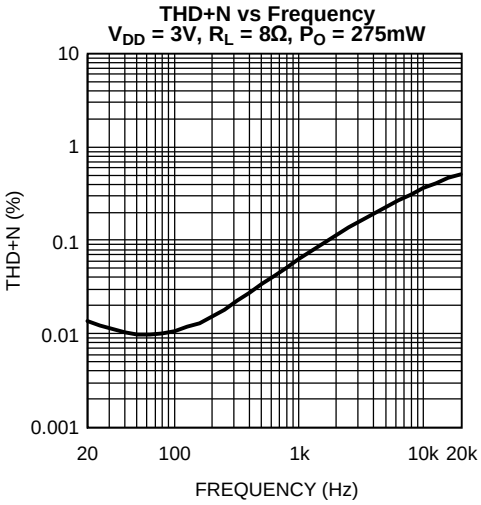



**Figure 7.**

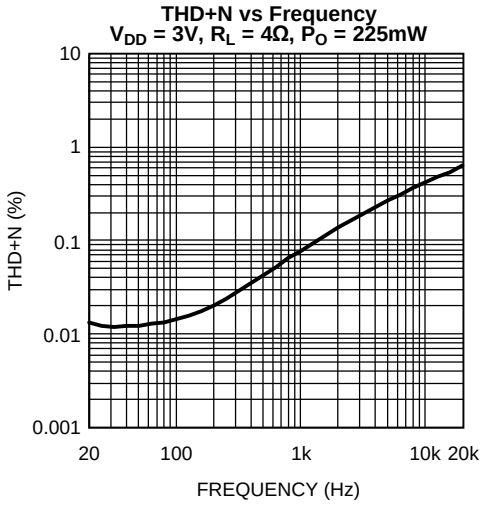



**Figure 8.**

(1) Data taken with BW = 80kHz and $A_V$ = 1/1 except where specified.


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## Typical Performance Characteristics(1) (continued)

THD+N vs Output Power
$V_{DD}$ = 2.6V, $R_L$ = 8Ω

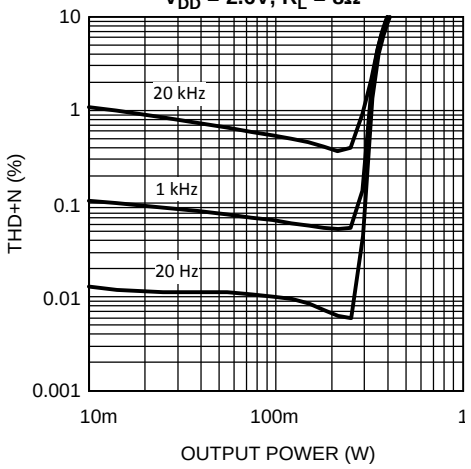



**Figure 9.**

THD+N vs Output Power
$V_{DD}$ = 2.6V, $R_L$ = 4Ω

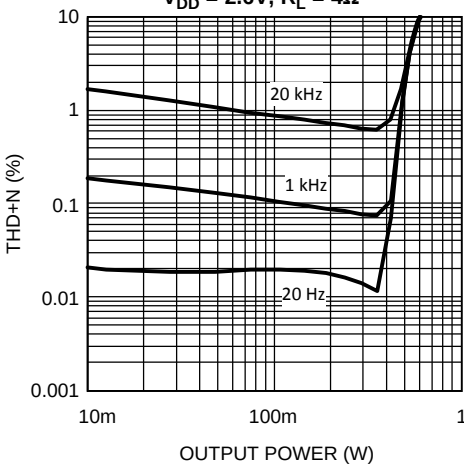



**Figure 10.**

THD+N vs Output Power
$V_{DD}$ = 5V, $R_L$ = 8Ω

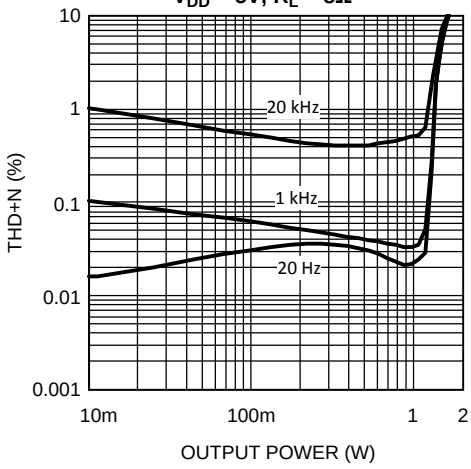



**Figure 11.**

THD+N vs Output Power
$V_{DD}$ = 5V, $R_L$ = 4Ω

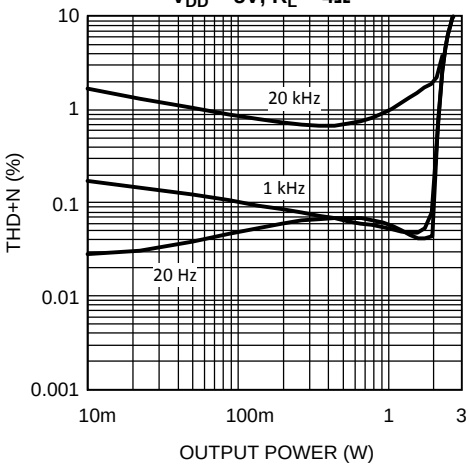



**Figure 12.**

THD+N vs Output Power
$V_{DD}$ = 3V, $R_L$ = 8Ω

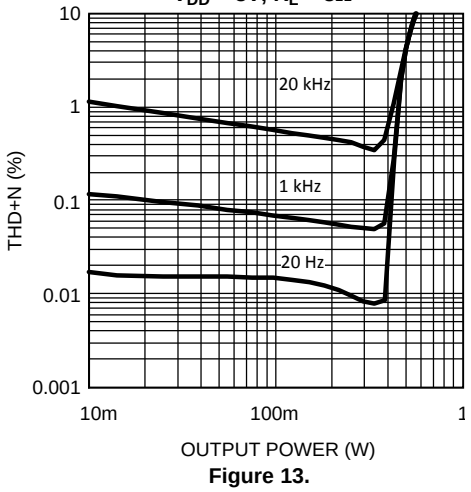



**Figure 13.**

THD+N vs Output Power
$V_{DD}$ = 3V, $R_L$ = 4Ω

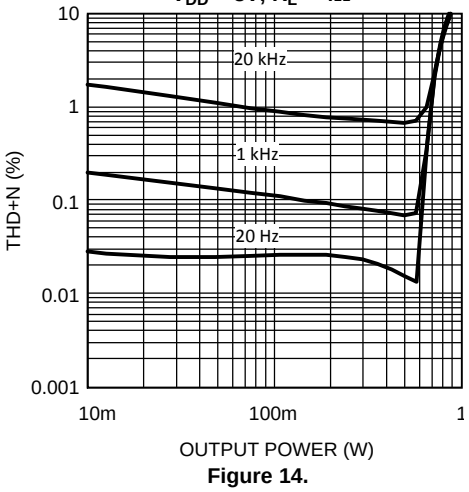



**Figure 14.**

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## Typical Performance Characteristics[1] (continued)

**PSRR vs Frequency**
**$V_{DD}$ = 5V, $R_L$ = 8Ω**
**Inputs terminated to GND, BW = 500kHz**

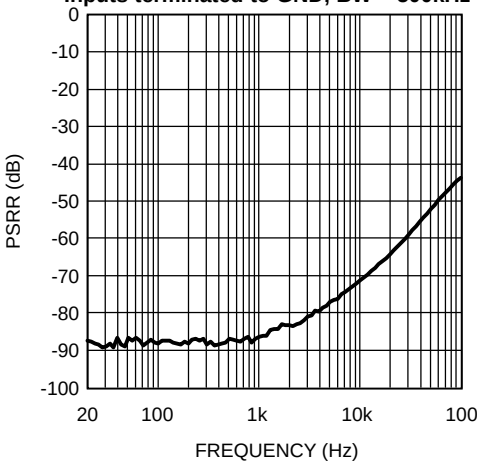



**Figure 15.**

**PSRR vs Frequency**
**$V_{DD}$ = 3V, $R_L$ = 8Ω**
**Inputs terminated to GND, BW = 500kHz**

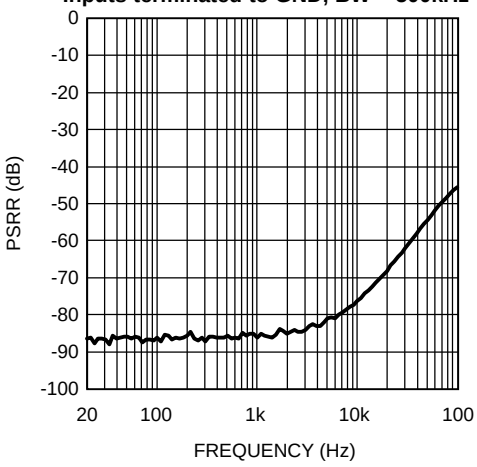



**Figure 16.**

**Output Power vs Supply Voltage**
**$R_L$ = 8Ω**

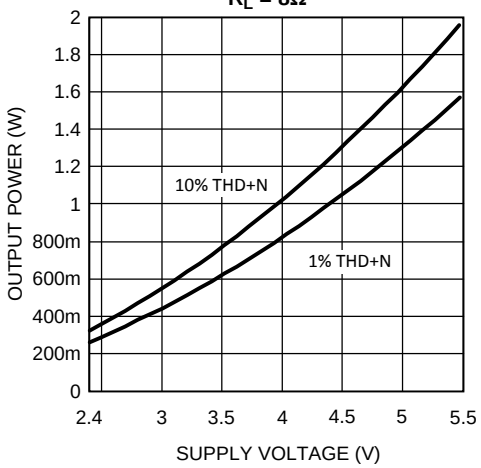



**Figure 17.**

**Output Power vs Supply Voltage**
**$R_L$ = 4Ω**

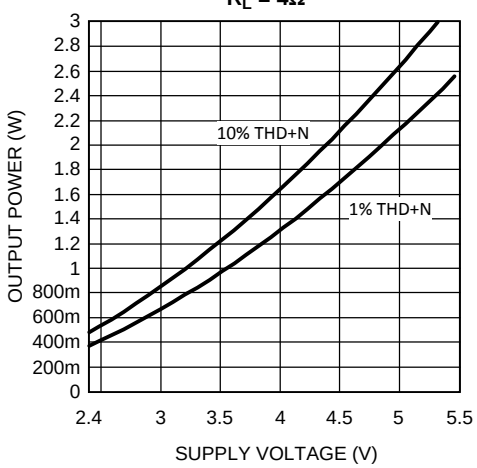



**Figure 18.**

**CMRR vs Frequency**
**$V_{DD}$ = 5V, $R_L$ = 8Ω**

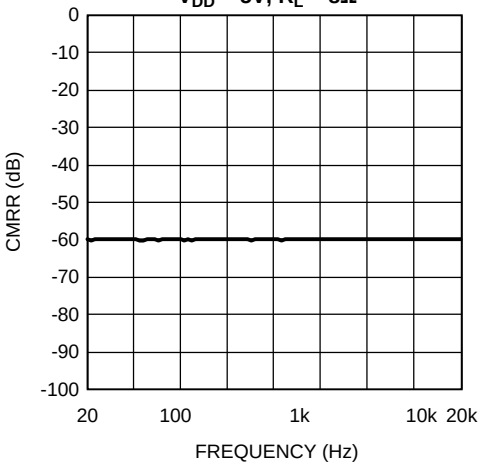



**Figure 19.**

**CMRR vs Frequency**
**$V_{DD}$ = 3V, $R_L$ = 8Ω**

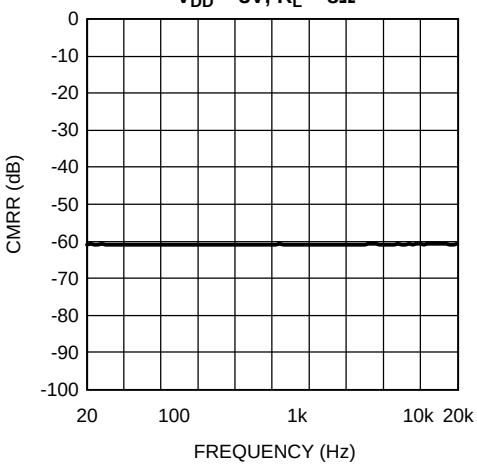



**Figure 20.**


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## Typical Performance Characteristics[1] (continued)

**PSRR vs Common Mode Voltage**
**$V_{DD}$ = 3V, $R_L$ = 8Ω, f = 217Hz**

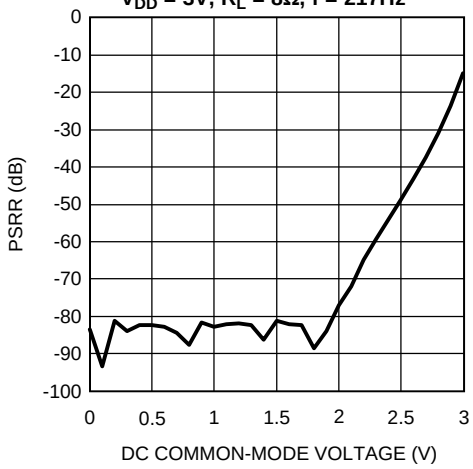



**Figure 21.**

**PSRR vs Common Mode Voltage**
**$V_{DD}$ = 5V, $R_L$ = 8Ω, f = 217Hz**

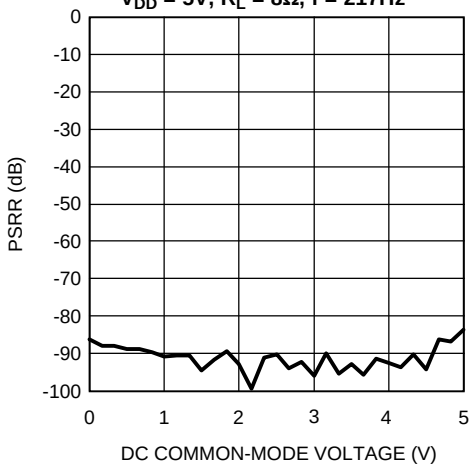



**Figure 22.**

**Power Dissipation vs Output Power**
**$V_{DD}$ = 2.6V, $R_L$ = 8Ω and 4Ω**

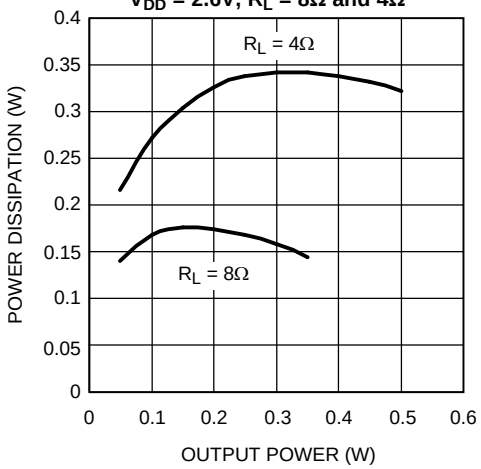



**Figure 23.**

**Power Dissipation vs Output Power**
**$V_{DD}$ = 5V, $R_L$ = 8Ω**

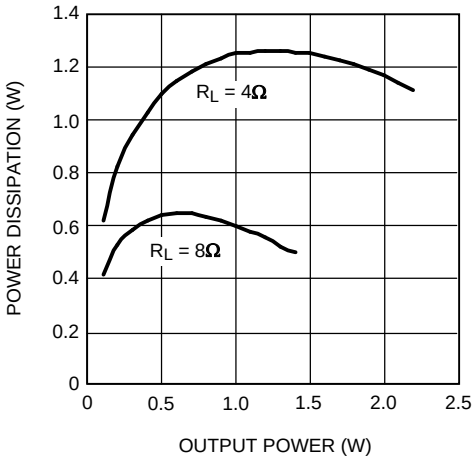



**Figure 24.**

**Power Dissipation vs Output Power**
**$V_{DD}$ = 3V, $R_L$ = 8Ω**

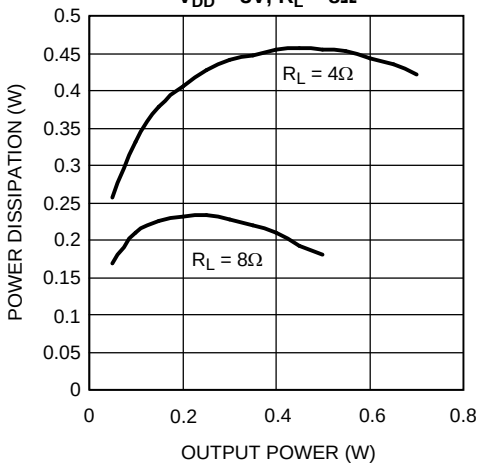



**Figure 25.**

**Power Derating Curve**

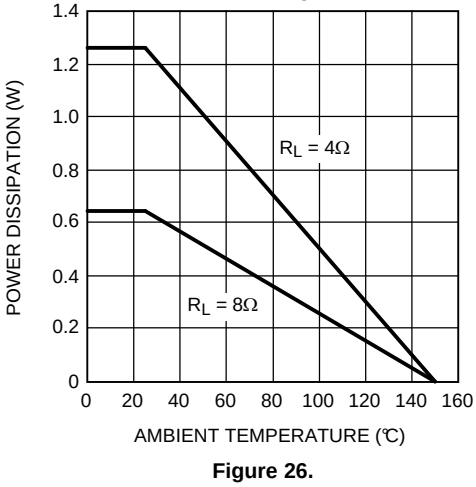



**Figure 26.**

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## Typical Performance Characteristics[1] (continued)

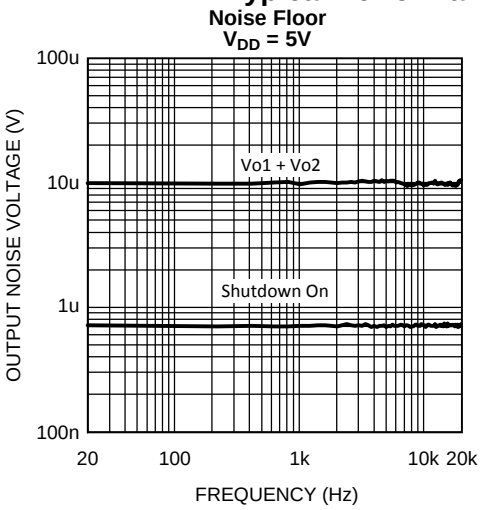



**Figure 27.**

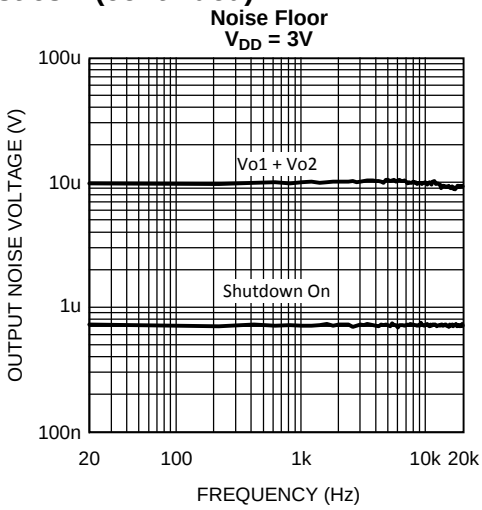



**Figure 28.**

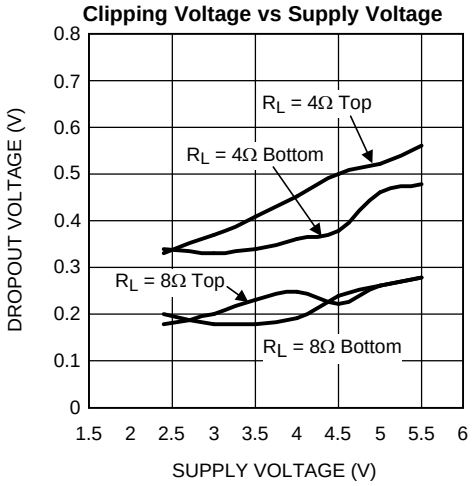



**Figure 29.**

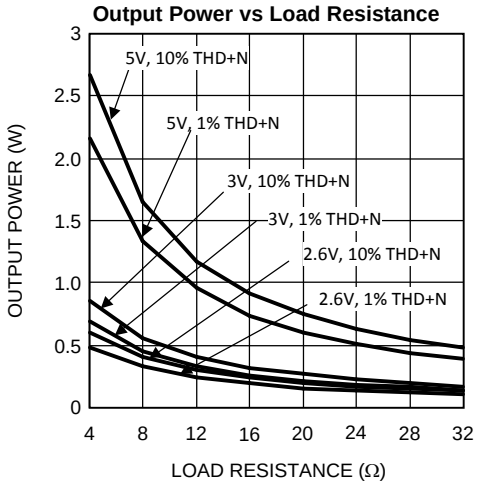



**Figure 30.**


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# APPLICATION INFORMATION

## DIFFERENTIAL AMPLIFIER EXPLANATION

The LM4927 is a fully differential audio amplifier that features differential input and output stages. Internally this is accomplished by two circuits: a differential amplifier and a common mode feedback amplifier that adjusts the output voltages so that the average value remains $V_{DD}$ / 2. When setting the differential gain, the amplifier can be considered to have "halves". Each half uses an input and feedback resistor ($R_{i1}$ and $R_{F1}$) to set its respective closed-loop gain (see Figure 1). With $R_{i1} = R_{i2}$ and $R_{F1} = R_{F2}$, the gain is set at $-R_F / R_i$ for each half. This results in a differential gain of

$$A_{VD} = -R_F/R_i \quad (1)$$

It is extremely important to match the input resistors to each other, as well as the feedback resistors to each other for best amplifier performance. See the PROPER SELECTION OF EXTERNAL COMPONENTS section for more information. A differential amplifier works in a manner where the difference between the two input signals is amplified. In most applications, this would require input signals that are 180° out of phase with each other. The LM4927 can be used, however, as a single ended input amplifier while still retaining its fully differential benefits. In fact, completely unrelated signals may be placed on the input pins. The LM4927 simply amplifies the difference between them.

All of these applications provide what is known as a "bridged mode" output (bridge-tied-load, BTL). This results in output signals at $V_{o1}$ and $V_{o2}$ that are 180° out of phase with respect to each other. Bridged mode operation is different from the single-ended amplifier configuration that connects the load between the amplifier output and ground. A bridged amplifier design has distinct advantages over the single-ended configuration: it provides differential drive to the load, thus doubling maximum possible output swing for a specific supply voltage. Four times the output power is possible compared with a single-ended amplifier under the same conditions. This increase in attainable output power assumes that the amplifier is not current limited or clipped. In order to choose an amplifier's closed-loop gain without causing excess clipping, please refer to the AUDIO POWER AMPLIFIER DESIGN section.

A bridged configuration, such as the one used in the LM4927, also creates a second advantage over single-ended amplifiers. Since the differential outputs, $V_{o1}$ and $V_{o2}$, are biased at half-supply, no net DC voltage exists across the load. This assumes that the input resistor pair and the feedback resistor pair are properly matched (see PROPER SELECTION OF EXTERNAL COMPONENTS). BTL configuration eliminates the output coupling capacitor required in single-supply, single-ended amplifier configurations. If an output coupling capacitor is not used in a single-ended output configuration, the half-supply bias across the load would result in both increased internal IC power dissipation as well as permanent loudspeaker damage. Further advantages of bridged mode operation specific to fully differential amplifiers like the LM4927 include increased power supply rejection ratio, common-mode noise reduction, and click and pop reduction.

## EXPOSED-DAP PACKAGE PCB MOUNTING CONSIDERATIONS

The LM4927's exposed-DAP (die attach paddle) package (WSON) provide a low thermal resistance between the die and the PCB to which the part is mounted and soldered. This allows rapid heat transfer from the die to the surrounding PCB copper traces, ground plane and, finally, surrounding air. Failing to optimize thermal design may compromise the LM4927's high power performance and activate unwanted, though necessary, thermal shutdown protection. The WSON package must have its DAP soldered to a copper pad on the PCB. The DAP's PCB copper pad is connected to a large plane of continuous unbroken copper. This plane forms a thermal mass and heat sink and radiation area. Place the heat sink area on either outside plane in the case of a two-sided PCB, or on an inner layer of a board with more than two layers. Connect the DAP copper pad to the inner layer or backside copper heat sink area with a thermal via. The via diameter should be 0.012in - 0.013in. Ensure efficient thermal conductivity by plating-through and solder-filling the vias.

Best thermal performance is achieved with the largest practical copper heat sink area. In all circumstances and conditions, the junction temperature must be held below 150°C to prevent activating the LM4927's thermal shutdown protection. The LM4927's power de-rating curve in the Typical Performance Characteristics shows the maximum power dissipation versus temperature. Example PCB layouts are shown in the Demonstration Board Layout section. Further detailed and specific information concerning PCB layout, fabrication, and mounting an WSON package is available from Texas Instruments' package Engineering Group under application note AN1187.

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## PCB LAYOUT AND SUPPLY REGULATION CONSIDERATIONS FOR DRIVING 4Ω LOADS

Power dissipated by a load is a function of the voltage swing across the load and the load's impedance. As load impedance decreases, load dissipation becomes increasingly dependent on the interconnect (PCB trace and wire) resistance between the amplifier output pins and the load's connections. Residual trace resistance causes a voltage drop, which results in power dissipated in the trace and not in the load as desired. This problem of decreased load dissipation is exacerbated as load impedance decreases. Therefore, to maintain the highest load dissipation and widest output voltage swing, PCB traces that connect the output pins to a load must be as wide as possible.

Poor power supply regulation adversely affects maximum output power. A poorly regulated supply's output voltage decreases with increasing load current. Reduced supply voltage causes decreased headroom, output signal clipping, and reduced output power. Even with tightly regulated supplies, trace resistance creates the same effects as poor supply regulation. Therefore, making the power supply traces as wide as possible helps maintain full output voltage swing.

## POWER DISSIPATION

Power dissipation is a major concern when designing a successful amplifer, whether the amplifier is bridged or single-ended. Equation 2 states the maximum power dissipation point for a single-ended amplifier operating at a given supply voltage and driving a specified output load.

$$P_{DMAX} = (V_{DD})^2 / (2\pi^2 R_L) \text{ Single-Ended} \quad (2)$$

However, a direct consequence of the increased power delivered to the load by a bridge amplifier is an increase in internal power dissipation versus a single-ended amplifier operating at the same conditions.

$$P_{DMAX} = 4 * (V_{DD})^2 / (2\pi^2 R_L) \text{ Bridge Mode} \quad (3)$$

Since the LM4927 has bridged outputs, the maximum internal power dissipation is 4 times that of a single-ended amplifier. Even with this substantial increase in power dissipation, the LM4927 does not require additional heatsinking under most operating conditions and output loading. From Equation 3, assuming a 5V power supply and an 8Ω load, the maximum power dissipation point is 625mW. The maximum power dissipation point obtained from Equation 3 must not be greater than the power dissipation results from Equation 4:

$$P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA} \quad (4)$$

The LM4927's $\theta_{JA}$ in an NGQ0008A package is 63°C/W. Depending on the ambient temperature, $T_A$, of the system surroundings, Equation 4 can be used to find the maximum internal power dissipation supported by the IC packaging. If the result of Equation 3 is greater than that of Equation 4, then either the supply voltage must be decreased, the load impedance increased, the ambient temperature reduced, or the $\theta_{JA}$ reduced with heatsinking. In many cases, larger traces near the output, $V_{DD}$, and GND pins can be used to lower the $\theta_{JA}$. The larger areas of copper provide a form of heatsinking allowing higher power dissipation. For the typical application of a 5V power supply, with an 8Ω load, the maximum ambient temperature possible without violating the maximum junction temperature is approximately 110°C provided that device operation is around the maximum power dissipation point. Recall that internal power dissipation is a function of output power. If typical operation is not around the maximum power dissipation point, the LM4927 can operate at higher ambient temperatures. Refer to the Typical Performance Characteristics curves for power dissipation information.

## POWER SUPPLY BYPASSING

As with any power amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection ratio (PSRR). The capacitor location on both the bypass and power supply pins should be as close to the device as possible. A larger half-supply bypass capacitor improves PSRR because it increases half-supply stability. Typical applications employ a 5V regulator with 10µF and 0.1µF bypass capacitors that increase supply stability. This, however, does not eliminate the need for bypassing the supply nodes of the LM4927. The LM4927 will operate without the bypass capacitor $C_B$, although the PSRR may decrease. A 1µF capacitor is recommended for $C_B$. This value maximizes PSRR performance. Lesser values may be used, but PSRR decreases at frequencies below 1kHz. The issue of $C_B$ selection is thus dependant upon desired PSRR and click and pop performance as explained in the section PROPER SELECTION OF EXTERNAL COMPONENTS.


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## SHUTDOWN FUNCTION

In order to reduce power consumption while not in use, the LM4927 contains shutdown circuitry that is used to turn off the amplifier's bias circuitry. The device may then be placed into shutdown mode by toggling the Shutdown Select pin to logic low. The trigger point for shutdown is shown as a typical value in the Supply Current vs Shutdown Voltage graphs in the Typical Performance Characteristics section. It is best to switch between ground and supply for maximum performance. While the device may be disabled with shutdown voltages in between ground and supply, the idle current may be greater than the typical value of 0.1µA. In either case, the shutdown pin should be tied to a definite voltage to avoid unwanted state changes.

In many applications, a microcontroller or microprocessor output is used to control the shutdown circuitry, which provides a quick, smooth transition to shutdown. Another solution is to use a single-throw switch in conjunction with an external pull-up resistor. This scheme ensures that the shutdown pin will not float, thus preventing unwanted state changes.

## PROPER SELECTION OF EXTERNAL COMPONENTS

Proper selection of external components in applications using integrated power amplifiers is critical when optimizing device and system performance. Although the LM4927 is tolerant to a variety of external component combinations, consideration of component values must be made when maximizing overall system quality.

The LM4927 is unity-gain stable, giving the designer maximum system flexibility. The LM4927 should be used in low closed-loop gain configurations to minimize THD+N values and maximize signal to noise ratio. Low gain configurations require large input signals to obtain a given output power. Input signals equal to or greater than 1Vrms are available from sources such as audio codecs. Please refer to the Audio Power Amplifier Design section for a more complete explanation of proper gain selection. When used in its typical application as a fully differential power amplifier the LM4927 does not require input coupling capacitors for input sources with DC common-mode voltages of less than $V_{DD}$. Exact allowable input common-mode voltage levels are actually a function of $V_{DD}$, $R_i$, and $R_f$ and may be determined by Equation 5:

$$V_{CMi} < (V_{DD}-1.2)*((R_f+(R_i)/(R_f)-V_{DD}*(R_i / 2R_f) \quad (5)$$

$$-R_F / R_I = A_{VD} \quad (6)$$

Special care must be taken to match the values of the input resistors ($R_{i1}$ and $R_{i2}$) to each other. Because of the balanced nature of differential amplifiers, resistor matching differences can result in net DC currents across the load. This DC current can increase power consumption, internal IC power dissipation, reduce PSRR, and possibly damaging the loudspeaker. The chart below demonstrates this problem by showing the effects of differing values between the feedback resistors while assuming that the input resistors are perfectly matched. The results below apply to the application circuit shown in Figure 1, and assumes that $V_{DD}$ = 5V, $R_L$ = 8Ω, and the system has DC coupled inputs tied to ground.

| Tolerance | $R_{i1}$ | $R_{i2}$ | $V_{02} - V_{01}$ | $I_{LOAD}$ |
|---|---|---|---|---|
| 20% | 0.8R | 1.2R | -0.500V | 62.5mA |
| 10% | 0.9R | 1.1R | -0.250V | 31.25mA |
| 5% | 0.95R | 1.05R | -0.125V | 15.63mA |
| 1% | 0.99R | 1.01R | -0.025V | 3.125mA |
| 0% | R | R | 0 | 0 |

Since the same variations can have a significant effect on PSRR and CMRR performance, it is highly recommended that the input resistors be matched to 1% tolerance or better for best performance.

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## AUDIO POWER AMPLIFIER DESIGN

### Design a 1W/8Ω Audio Amplifier

| Given: | |
|---|---|
| Power Output | 1Wrms |
| Load Impedance | 8Ω |
| Input Level | 1Vrms |
| Input Impedance | 20kΩ |
| Bandwidth | 100Hz–20kHz ± 0.25dB |

A designer must first determine the minimum supply rail to obtain the specified output power. The supply rail can easily be found by extrapolating from the Output Power vs Supply Voltage graphs in the Typical Performance CharacteristicsTypical Performance Characteristics(1) section. A second way to determine the minimum supply rail is to calculate the required $V_{OPEAK}$ using Equation 7 and add the dropout voltages. Using this method, the minimum supply voltage is (Vopeak + ($V_{DO\ TOP}$ + ($V_{DO\ BOT}$ )), where $V_{DO\ BOT}$ and $V_{DO\ TOP}$ are extrapolated from the Dropout Voltage vs Supply Voltage curve in the Typical Performance Characteristics section.

$$V_{opeak} = \sqrt{(2R_L P_O)} \tag{7}$$

Using the Output Power vs Supply Voltage graph for an 8Ω load, the minimum supply rail just about 5V. Extra supply voltage creates headroom that allows the LM4927 to reproduce peaks in excess of 1W without producing audible distortion. At this time, the designer must make sure that the power supply choice along with the output impedance does not violate the conditions explained in the POWER DISSIPATION section. Once the power dissipation equations have been addressed, the required differential gain can be determined from Equation 8.

$$A_{VD} \geq \sqrt{(P_O R_L)}/(V_{IN}) = V_{orms}/V_{inrms} \tag{8}$$

$$R_f / R_i = A_{VD} \tag{9}$$

From Equation 8, the minimum $A_{VD}$ is 2.83. A ratio of $R_f$ to $R_i$ of 2.83 gives $R_i$ = 14kΩ. The final design step is to address the bandwidth requirement which must be stated as a single -3dB frequency point. Five times away from a -3dB point is 0.17dB down from passband response which is better than the required ±0.25dB specified.

$$f_H = 20kHz * 5 = 100kHz \tag{10}$$

The high frequency pole is determined by the product of the desired frequency pole, $f_H$ , and the differential gain, $A_{VD}$ . With a $A_{VD}$ = 2.83 and $f_H$ = 100kHz, the resulting GBWP = 150kHz which is much smaller than the LM4927 GBWP of 10MHz. This figure displays that if a designer has a need to design an amplifier with a higher differential gain, the LM4927 can still be used without running into bandwidth limitations.

## Revision History

| Rev | Date | Description |
|---|---|---|
| 0.1 | 06/01/05 | 1st time WEB release for this project. (MC) |
| 0.2 | 04/07/06 | Edited the Rf spec (5V EC table) to reveal max and min limits of 47 and 37 kΩ respectively (per Bic and Daniel). |
| 0.3 | 04/14/06 | Added Ri = 40kohm (Conditions for Rf) per Bic and WC Pua, then re-released D/S. |
| B | 04/05/13 | Changed layout of National Data Sheet to TI format |

(1) Data taken with BW = 80kHz and $A_V$ = 1/1 except where specified.


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## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM4927SD/NOPB | Active | Production | WSON (NGQ) \| 8 | 1000 \| LARGE T&R | Yes | SN | Level-1-260C-UNLIM | - | L4927 |
| LM4927SD/NOPB.A | Active | Production | WSON (NGQ) \| 8 | 1000 \| LARGE T&R | Yes | SN | Level-1-260C-UNLIM | See LM4927SD/NOPB | L4927 |

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

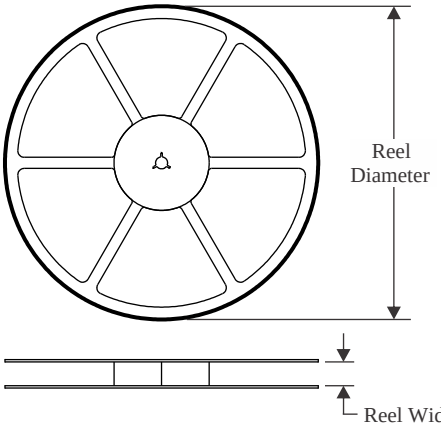
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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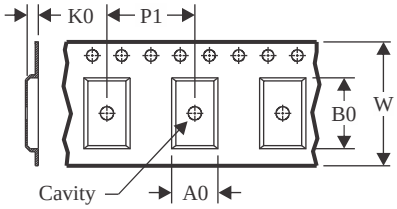
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## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

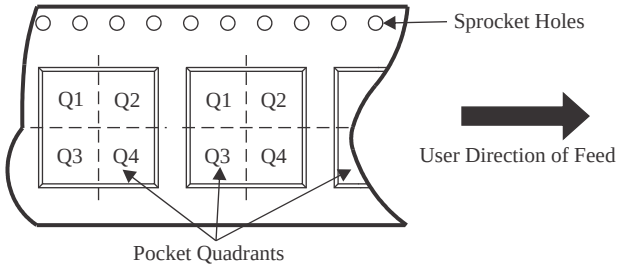



**TAPE DIMENSIONS**




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

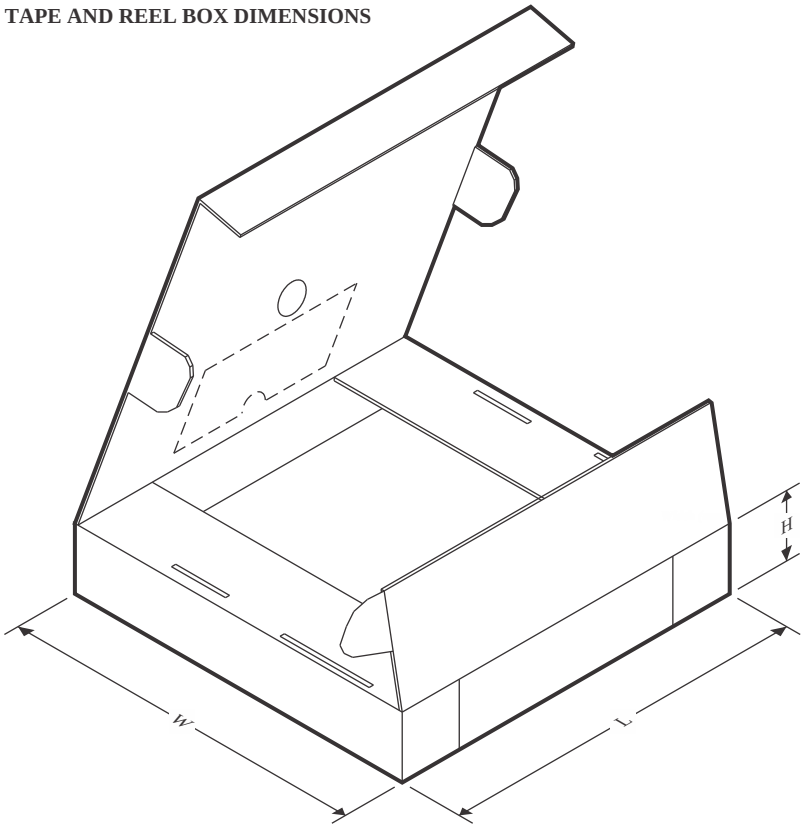
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM4927SD/NOPB | WSON | NGQ | 8 | 1000 | 177.8 | 12.4 | 3.3 | 3.3 | 1.0 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

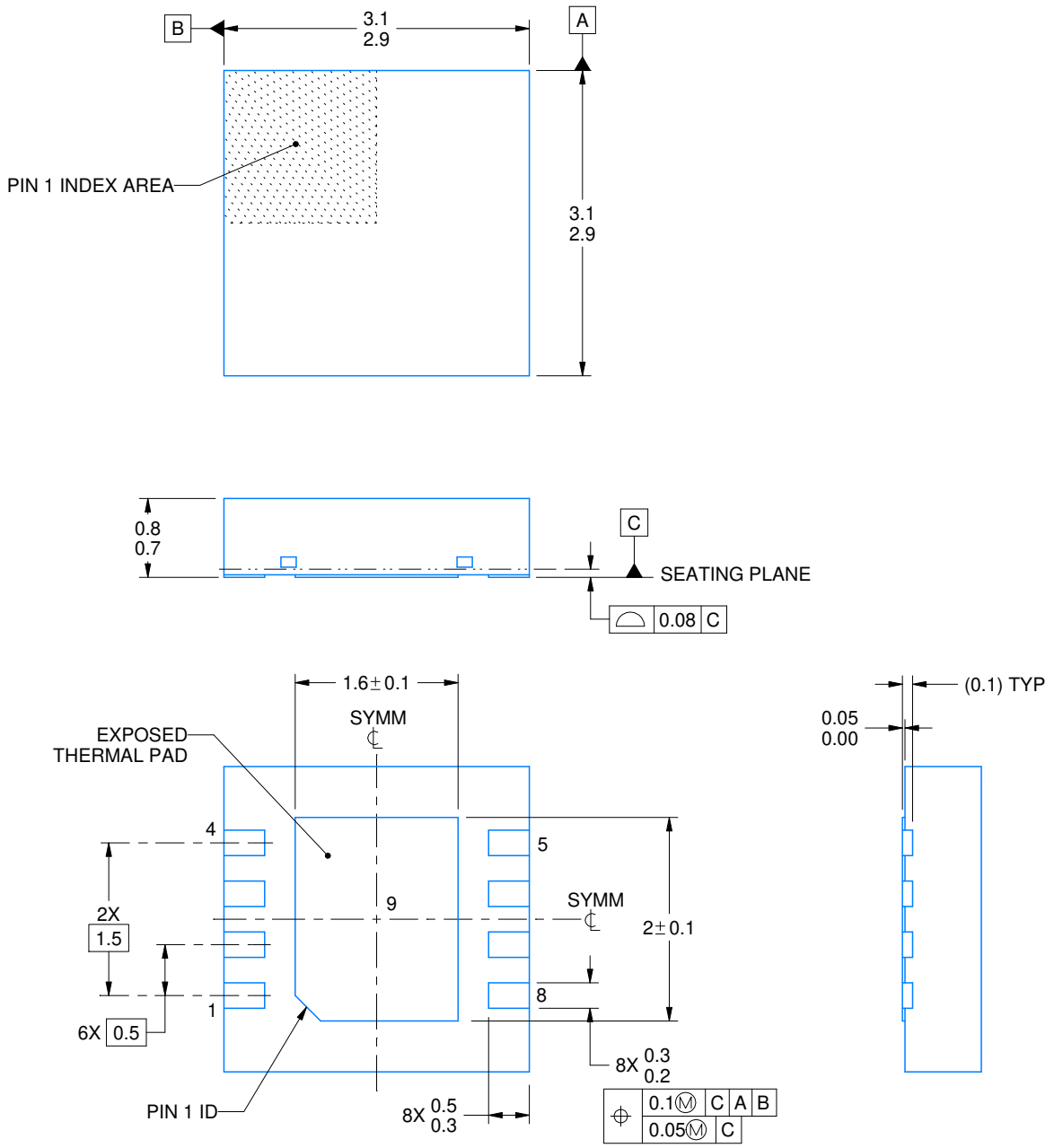
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LM4927SD/NOPB | WSON | NGQ | 8 | 1000 | 208.0 | 191.0 | 35.0 |

# PACKAGE OUTLINE

## NGQ0008A

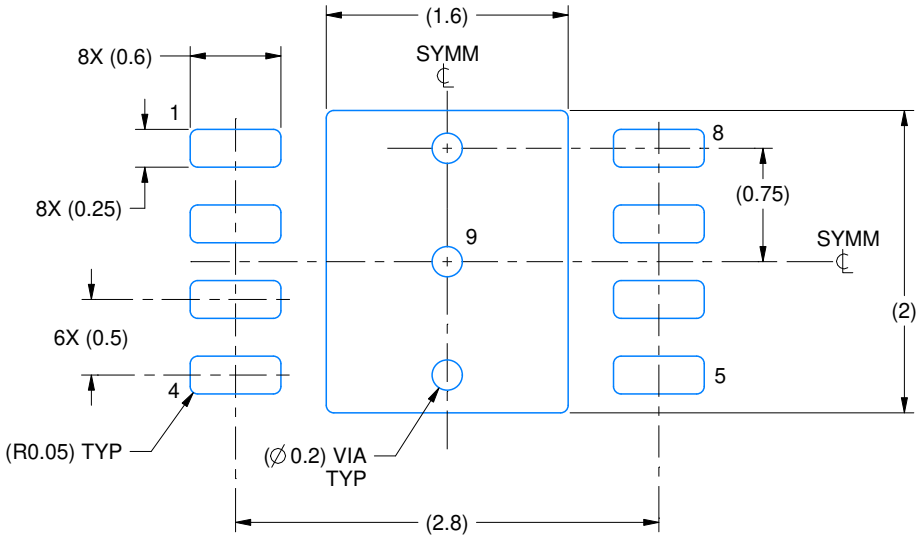
## WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD

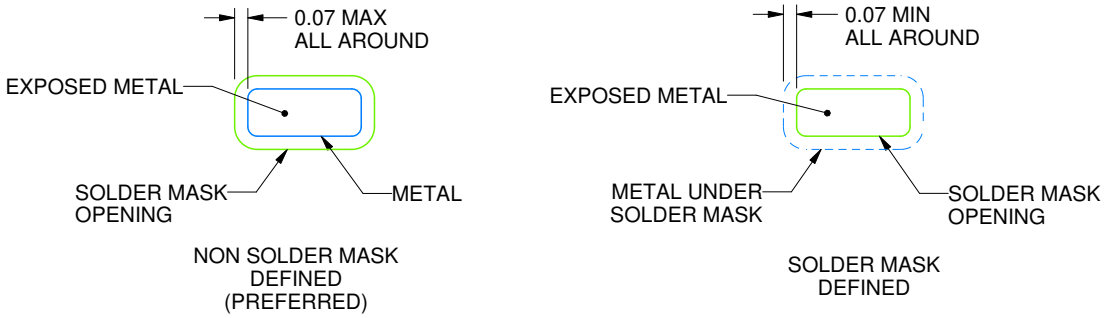



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:20X

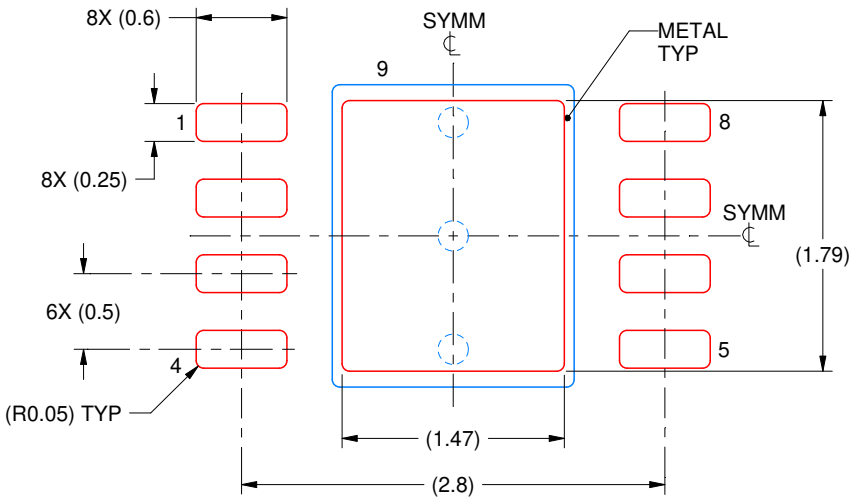



SOLDER MASK DETAILS

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NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.




SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL

EXPOSED PAD 9:
82% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4214922/A 03/2018

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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